An Biometric Identification System by Extracting Hand Vein Patterns

Sang-Kyun IM, Hyung-Man PARK*, Young-Woo KIM, Sang-Chan HAN, Soo-Won KIM and Chul-Hee KANG
Department of Electronics Engineering, Korea University, Seoul 136-701

Chang-Kyung CHUNG
BK System Co., Ltd, Seoul 137-130

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This paper presents an ASP (application specific processor) for vein pattern extraction and its application to a biometric identification system. For the conventional vein pattern extracting algorithm, it is necessary to use a high-priced DSP processor suitable for a floating-point operation and a real-time process. The proposed processor adopts a shift-and-add architecture for filters, so the preprocessing algorithm can be done with a fixed-point operation, and the filter coefficients are designed with 7-tap CSD codes. A reliability of 99.45% and a verification speed of 150 ms/person were obtained, which demonstrated enhanced performance compared to the conventional algorithm. The processor was implemented using a FPGA (field programmable gate array) device. If the price and the performance of recognition are considered, the proposed biometric identification system is applicable to personal identification systems, security systems, etc.

I. INTRODUCTION

There are many types of biometric systems commercially available such as fingerprints, iris/retina and hand shape devices. Each of these systems has merits and demerits. In the case of fingerprints, direct contact of the finger with the fingerprint-image-extracting sensor causes degradation in performance, especially in factory construction sites where good-quality fingerprints are hard to obtain due to oil from the finger, moisture, dirt, etc. In the case of iris/retina scanners, users must place the eye close to the scanner, causing an uncomfortable feeling or privacy-infringing feeling. In the case of hand-shape recognizers, problems may arise with users who suffer from arthritis or rheumatism, so they are rarely used due to their poor performance [1,2]. The proposed method has been developed to resolve the problems stated above. Since it acquires a vein pattern image without direct contact with the hand or with the vein-pattern-extracting sensor, there exists no contamination. Both user comfort and performance are improved, and stable operation is also expected.

In this paper, a new, low-priced, biometric identification system using this new method is proposed. Also, if a conventional vein-pattern-extracting algorithm is to be realized, the use of a high-priced DSP (digital signal processor) is inevitable since the algorithm includes a floating-point operation and should be a real-time process. To resolve this problem, we propose a new preprocess algorithm which takes 7-tap filter coefficients for which CSD (canonical signed digit) codes [3-5] are used. The filter is designed with a shift-and-add architecture and is only comprised of fixed-point operators. Also, the preprocessing and recognition time is remarkably improved using filters with different kernel sizes. This new preprocess makes it possible to reduce the number of access times to the external memory, and the filtering is preprocessed only a single time, not repeatedly.

After analyzing the conventional algorithm in Section II, the proposed algorithm and architecture of the processor are discussed in Section III-1. The whole architecture of the proposed biometric identification system is described in Section III-2; then, the performance is evaluated from the experimental results in Section IV. The obtained results are summarized in Section V.

II. CONVENTIONAL ALGORITHM

The conventional vein-pattern-recognition algorithm [5] consists of an original image grab part, a preprocessing part, and a recognition part, and the last two parts take most of the processing time. The preprocessing part consists of a Gaussian low-pass filter, a high-pass filter, and a modified median filter. Figure 1 shows the flow of the conventional preprocessing algorithm.

*E-mail: hmpark@asic.korea.ac.kr
The Gaussian low-pass filter applies a $3 \times 3$ spatial filter, repeatedly, on the ROI (region of interest) image as shown in Fig. 2. $Z(5)$ can be determined from Eq. (1).

$$Z(5) = \sum_{i=1}^{9} W(i)Z(i) \quad (1)$$

Then, the high-pass filter applies a $11 \times 11$ spatial filter to the ROI image. By applying the two filters above, we obtain an image with only the vein pattern emphasized. The local threshold process, then, separates the vein pattern from the background; hence, the desired vein image is extracted. Then, the normalization step is done utilizing the conventional bilinear interpolation.

A brief review of the conventional preprocessing method explained above indicates that floating-point multipliers and dividers are needed for all of the filtering processes. Also, a high-priced DSP is needed, considering the preprocessing time. If a 32-bit, floating-point, ADSP-2106X were to be used, the preprocessing time would be 700 ms/person. Therefore, a floating-point DSP with higher performance should be used in order to achieve a preprocessing time less than 700 ms/person.

### III. DESIGN OF THE ASP

1. Proposed Preprocessing Algorithm and Processor Architecture

The proposed ASP (application specific processor) for

![Fig. 3. Architecture of the proposed filter (shifter and adder).](image3)

![Fig. 4. Block diagram of the proposed processor.](image4)
Fig. 5. Block diagram of the proposed biometric identification system.

vein pattern extraction adopts a new preprocessing algorithm while maintaining the performance of the conventional one. Both the coefficients for the Gaussian low-pass filter and the low-pass filter are designed to have 7-tap CSD codes at the maximum. Also, for the normalization, the decimation method is used. The CSD code is an effective code for designing a FIR filter without a multiplier.

The proposed preprocessing algorithm follows the same steps as the conventional one in section II, except that the coefficients for each filter are made of CSD codes. The general CSD code is equal to

$$W_j = \sum_{i=1}^{M_j} S_i 2^{-i}$$

where $j = 1, 2, \ldots, 121$, $S_i \in \{-1, 0, 1\}$ and $M$ is an integer.

In the first step of the preprocessing, Gaussian low-pass filter, a $11 \times 11$ spatial filter is applied on a grabbed ROI image only a single time rather than applying a $3 \times 3$ spatial filter repeatedly. With this newly proposed way, access times to the external memory are reduced. The filter consists of 7-tap CSD codes at the maximum, which can be realized using a shift-and-add architecture. In the second step, the low-pass filter is applied with a $11 \times 11$ spatial filter, and the filter coefficients are designed to compensate for the rounding-effect due to the CSD code operations in the Gaussian low-pass filter. This low-pass filter also has 7-tap CSD codes at the maximum.

As stated above, if the same kernel-size is utilized for both filters, a sequentially applied filtering process can be realized with one piece of hardware, which is a great advantage in terms of decreasing hardware complexity. The third step is the normalization that uses the decimation method, the same as down sampling, to prevent certain vein patterns from distortion. The shift-and-add architecture utilizing the CSD code is shown in Fig. 3, and the block diagram of the proposed processor is shown in Fig. 4.

2. Architecture of Proposed Biometric Identification System

A VPRS (vein pattern recognition system) using the proposed processor was implemented as shown in Fig. 5. The system architecture consisted of a user interface block, a microprocessor for system control, an ASP for vein pattern extraction, and a memory for processing the algorithm. The user interface block takes a user’s PIN (personal identification number) as an input and indicates the verification result if the user is permitted or rejected in the recognition mode and is registered or deleted in the registering mode. The microprocessor manages the users’ DB (databases), such as the DB register, DB delete, and administration of supervisors and managers, and controls the proposed processor. The ASP for vein pattern extraction takes five steps:
1. Extracts a region where hand vein patterns are concentrated and defines this region as the ROI (see Fig. 6.),

2. Processes the proposed preprocessing algorithm step by step on the grabbed ROI image and produces an image with only the vein pattern emphasized,

3. Applies a local threshold process and separates the vein pattern from the background, which results in the first vein pattern image (see Fig. 7.),

4. Applies a modified median filter so the noise caused by hair, curvatures, and thickness of fatty substances under the skin is removed (see Fig. 8.),

5. Stores the final vein pattern image after the normalization and the database process are finished.

**IV. EXPERIMENTAL RESULTS**

Applying the conventional algorithm to 5000, gray-scaled, ROI images, each with 160 × 120 pixel, we obtained 5000 images of extracted vein patterns to be utilized for a reference. We also generated 100 CSD codes and selected 10 highly reliable ones for filter coefficients. Also, the proposed Gaussian filter with these optimal coefficients was applied to the 5000 ROI images to obtain images of 94.88 % the same as the reference images. Defining the reliability as the percentile in which an image is identical with the reference one, it can be said that the proposed Gaussian filter is 94.88 % reliable. In addition, for the coefficients of the low-pass filter, we selected CSD codes that compensated for the errors occurring in the Gaussian low-pass process due to the rounding effect. Using both the proposed Gaussian low-pass filter and the low-pass filter, a reliability of 99.45 % was obtained. In addition, since both filters are designed to be of the same kernel size, hardware area is saved by using a single shift-and-add architecture.

**V. CONCLUSIONS**

Using the proposed biometric system, we have investigated FAR [6,7] for randomly selected 10,000 people. (See Fig. 9: Randomly sampled FAR test results.) the FAR is adjustable by changing the threshold level, and the maximum value of the FAR is 0.001 %. As shown in Fig. 9, the conventional and the proposed biometric systems exhibit exactly the same FAR performance. The verification speed was measured to be 150 ms/person without an expensive DSP or a PC.

In this paper, a new, low-priced, biometric system has been proposed (See Fig. 10.), and the system is applicable to personal identification and security systems. Future work includes improving the performance of the vein-pattern-extracting algorithm. Also, the method for compensating for the edge of the vein pattern must be studied.

**REFERENCES**


